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EFFECT OF SHAPE OF STEEL FIBRE ON MECHANICAL PROPERTIES OF FIBRE REINFORCED CONCRETE

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Abstract : Concrete is a composite material composed of coarse aggregate bonded together with fluid cement that hardens over time. Concrete has relatively high compressive strength, than the tensile strength. For this reason it is usually reinforced with materials that are strong in tension. The tensile strength of the concrete can be increased by the addition of the glass fibers, steel fibers, nylon fibers etc.

In this project we are aimed to study the effect of shape of steel fibers on mechanical properties of fiber reinforced concrete. For this purpose M30 grade concrete is chosen as the mix. Different shapes of fibers like hooked end, crimped are used in thisstudy as an addition in percentage likes 1%, 2%, 3%, and 4% to the weight of cement. From the test results we came to conclusion that the Mix with crimped shaped fibre shows more resistance to both compressive and split tensile strength than the Mixes with hooked shaped fibre and conventional at an percentage of 2% with the weight of cement. In comparison use of crimped shapes fibre in concrete gives more satisfactory results than the hooked shaped fibre

***IndexTerms* –fibre reinforced concrete, mechanical properties, steel fibres, durability.**

1 INTRODUCTION

CONCRETE

Concrete is one of the most commonly used building materials and Concrete is versatile material that can easily be mixed to meet a variety of special needs and formed to virtually any shape.
Concrete is a composite material composed of aggregate bonded together with a fluid cement that hardens over time. Most concretes used are lime-based concretes such as Portland cement concrete or concretes made with other hydraulic cements. However, asphalt concrete, which is frequently used for road surfaces, is also a type of concrete, where the binding material is bitumen, and polymer concretes are sometimes used where the cementing material is a polymer.

1.1 Ordinary Portland cement

Portland cement is the most common type of cement in general use around the world, used as a basic ingredient of concrete, mortar, stucco, and most non-specialty grout. It developed from other types of hydraulic lime in England in the mid-19th century and usually originates from limestone. It is a fine powder produced by heating materials in a kiln to form what is called clinker, grinding the clinker, and adding small amounts of other materials. Several types of Portland cement are available with the most common being called as ordinary Portland cement (OPC) which is grey in colour, but white Portland cement is also available.

1.2 Merits and demerits of concrete

1.2.1 Some Merits of concrete are given below in brief

- Concrete is economical when ingredients are readily available.
- Concrete’s long life and relatively low maintenance requirements increase itseconomical benefits.
- It is not as likely to rot, corrode, or decay as other building materials.
- Concrete has the ability to be moulded or cast into almost any desired Shape.

- Building of the moulds and casting can occur on the work-site which reducescost.
- Concrete is a non-combustible material which makes it fire-safe and able towithstand high temperatures.
- It is resistant to wind, water, rodents, and insects. Hence, concrete is oftenused for storm shelters.

1.2.2 *Some Demerits of concrete are given below in brief.*

Concrete has some disadvantages too along the advantages stated above.

- The concrete has a relatively low tensile strength.
- And also the concrete has low ductility.
- Low strength-to-weight ratio and Concrete is susceptible to cracking.

1.3 *Applications of fiber in concrete*

Concrete is weak in tension and has a brittle character. The concept of using fibers to improve the characteristics of construction materials is very old. Early applications include addition of straw to mud bricks, horse hair to reinforce plasterand asbestos to reinforce pottery. The modern development of fiber reinforced concrete (FRC) started in the early sixties. Addition of fibers to concrete makes it a homogeneous and isotropic material. When concrete cracks, the randomly oriented fibers start functioning, arrest crack formation and propagation, and thus improve strength and ductility.

The uniform dispersion of fibers throughout the concrete mix provides isotropic properties not common to conventionally reinforced concrete. The applications of fibers in concrete industries depend on the designer and builder in taking advantage of the static and dynamic characteristics of this new material. The main area of FRC applications are

1.3.1 *Runway, Aircraft Parking, and Pavements*

1.3.2 *Tunnel Lining and Slope Stabilization*

1.3.3 *Blast Resistant Structures*

1.3.4 *Thin Shell, Walls, Pipes, and Manholes*

1.3.5 *Dams and Hydraulic Structure*

2.LITERATURE REVIEW

Published literature on fibre reinforced concrete first appeared in 1960, and has been increasing significantly since that time reflecting the amount of research and practical applications taking place. This chapter summarizes the most important published information of direct relevance to the experimental work reported in this project. As present investigation deals with the effect on mechanical properties with replacement of cement content with different shapes of steel fiber.

Nanni and Johari (1989) conducted an experiment for pavement construction using steel fibre reinforced concrete (SFRC). The concrete matrix contained fly ash, either Class F (used as a filler) or Class C (used as a binder). He had presented compression and split tension results of laboratory cylinders and field cores reinforced with different types of steel fibre in various percentages. It was found that post-cracking characteristics were greatly enhanced by fibres beyond ultimate strength and also concluded that 19 toughness indexes can be obtained from stress-strain curves in split tension test.

3. MATERIALS AND METHODOLOGY

CEMENT: A cement is a binder, a chemical substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel together.

- In this study, Cement of 53 grade Ordinary Portland Cement was used for the entire work.

PROPERTIES:

- Specific gravity of cement :3.12
- Fineness of cement :7%
- Normal consistency :33%
- Intial setting time of cemet :30min

Fig 3.1 CEMENT

FINE AGGREGATE:

- Locally available natural (river) sand confirming to IS specifications was used as a fine aggregate in the concrete mix.

PROPERTIES:

- Specific gravity of fine aggregate :2.6
- Water obsorption of fine aggregate :1%
- Fineness modulus of fine aggregate :

COARSE AGGREGATE:

- Coarse aggregate refer to irregular and granular materials such as sand, gravel, or crushed stone, and are used for making concrete. In most cases, Coarse is occurring and can be obtained by blasting quarries or crushing them by hand or crushers.
- In our project coarse aggregate of 20mm size is used

PROPERTIES:

- Specific gravity of coarse aggregate :2.74
- Water obsorption of coarse aggregate :0.5%

Water

In general, for concrete production potable water is used. Waste water from industrial units, sewage and other polluted areas should not be used in concrete. If the quality of water is doubted, then it should be tested before its use.

Steel fibres

In general the steel fibres are used to increase the tensile strength of the concrete. Wehave different shapes of steel fibres like straight fibre, crimped fibre, stranded fibre, hooked fibre and twisted fibre. Among these we are using hooked and crimpledfibres.

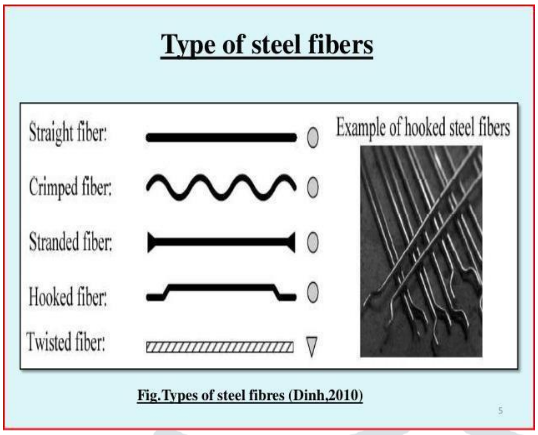

Fig. 3.5 : Different shapes of fibres

3.1.1.1 *Hooked fibre*

In general hooked end steel fibers are designed especially for the reinforcement of the concrete, mortars, other cementanious mixes

Properties of Hooked fibers

Nominal dimensions

Diameter D =0.60mm

Length =30mm

Aspect ratio L/D =50

Tensile strength of fiber is greater than >1450mpa

Strain at failure <4%

Crimped fibers

These are another form of steel fibers having undulations along the length of the fiber.

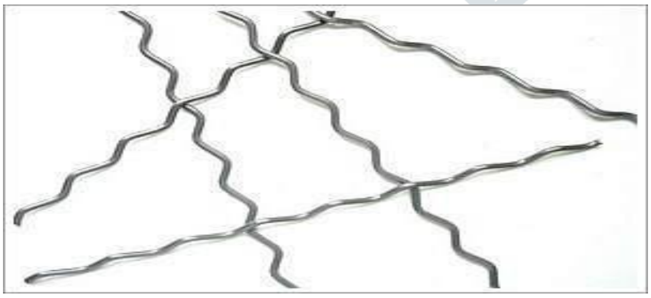

Fig. 3.7: Crimped fibres

Properties of crimped fibers

Nominal dimensions

Diameter =0.60mm

Length =30mm

Aspect ratio L/D =50

Tensile strength of crumbled fiber is >1400mpaStrain at failure is <4%

Applications of steel fibers

1.precast concrete applications.

2.shortcrete , tunnel linings and slope stabilization

3.Bridge decks and pavements

Test methods

This part describes the methods that are followed to test the fresh and hardened properties of the FRC

3.2.1 *Tests on Fresh Properties of FRC*

This section explains various tests that are to be done to fresh concrete to measurethe fresh properties such as filling ability, segregation resistance.

3.2.1.1 *Slump cone Test*

Slump test is the most commonly used method of measuring consistency of concrete in laboratory as well as at site of work. The apparatus for conducting the slump test consists of a metallic mould in the form of a frustum of a cone having the internal dimensions as under:
Bottom diameter: 200 mmTop diameter : 100 mm Height : 300 mm
For tamping the concrete, a steel tamping rod 16 mm dia, 0.6 meter long with bullet end is used.

The mould is then filled in four layers, (ASTM also specifies 3 layers.) each approximately 1/ 4 of the height of the mould. Each layer is tamped 25 times by the tamping rod.

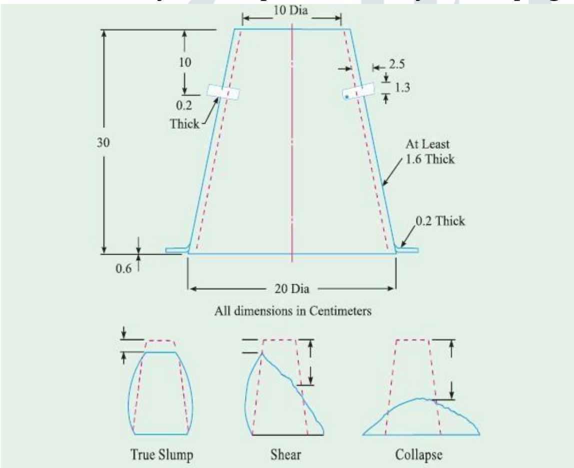

Fig. 3.7: Slump cone apparatuses

After the top layer has been rodded, the concrete is struck off level with a trowel and tamping rod. The mould is removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allows the concrete to subside (collapse). This subsidence is referred as SLUMP of concrete.
The difference in level between the height of the mould and that of the highest point of the subsided concrete in mm. is taken as Slump of Concrete. The slump test is very useful on site to check day-to-day or hour to- hour variation in the quality of mix. An increase in slump, may mean for instance that the moisture content of the aggregate has suddenly increased or there has been sudden change in the grading of aggregate.

3.3 LABORATORY TEST CONDUCTED:-

3.3.1 Compressive Strength Test

For cubes were cast to determine 7 days, and 28 days compressive strength after curing. The cubes were casted to know the compressive strength of concrete. The size of a cube is as per the IS 10086 – 1982.

3.3.2 Split tensile strength

The load was gradually applied on the specimen till the failure of the specimen occurs. The load at which failure of the specimen takes place is noted. The split tensile strength (for) of the concrete was calculated as follows:

$fa=2P/(\pi ld)$

CONCRETE MIX

mix design for concrete as per IS 10262-2009:

a) *Design stipulations*

Characteristic compressive strength required in the field at 28 days : 30Mpa

1. Maximum size of aggregate : 20mm
2. Degree of quality control : Good
3. Type of exposure : Moderate

b) *Tested data for materials*

Specific gravity of cement : 3.13

Specific gravity of Coarse aggregates : 2.7

Specific gravity of Fine aggregates : 2.65

Water absorption of coarse aggregate : 0.5%

Water absorption of fine aggregate : 1%

Free moisture in CA & FA :Nill

a) Target mean strength of concrete

The target mean strength for specified characteristic cube strength is30+1.65*5=38.25N/mm^2

b) *Selection of water - cement ratio*

The free w/c ratio required for the target mean strength of 38.25N/mm^2 is 0.45 The maximum free water-cement ratio for moderate exposure is 0.55 The free w/c ratio is taken as the minimum of the above two values,

i.e. w/c ratio =0.45

c) *w/c ratio adjustments*

For zone II sand we don't want to do any adjustments on the water cement ratio.

d) *Selection of water content*

From IS method for 20mm max size of aggregate, Sand conforming to grading Zone II. Water content per cubic meter of concrete = 186lit(for 25 to 50mm slump range)Maximum water content = 186kg/m^3 of concrete

For every additional 25mm slump increased by 3%

Estimated water content for 75mm slump = 180*3 / 100 =5.58

Water content =5.58+186

=191.58

Adopt Water content =190lit /m^3

e) *Determination of cement content*

W/C ratio =0.45

Water = 190lit /m^3

Cement = 190/0.45 =422.22kg/m^3 <450kg/m

s of fine aggregate =0.655×0.37×2.65×1000

=642.22kg/m^3

Table 4.1. Mix proportion

Water		cement		Fine aggregate		Coarse aggregate
186lit		422.22kg		642.22kg		1130.661kg
0.45	:	1	:	1.52	:	2.67

Hence the Mix is **1:1.57:2.67** (Designed for M30)

Table 4.1: M30 mix proportion for both Hooked and crumbled fibre for 1m^3 ofconcrete

% of fibre	Cement(Kg)	Fine agg (Kg)	Coarse agg(Kg)	Water (lit)	Amount of fibre (Kg)
0%	422.22	642.22	1130.66	190	0
1%	422.22	642.22	1130.66	190	4.22
2%	422.22	642.22	1130.66	190	8.44
3%	422.22	642.22	1130.66	190	12.66
4%	422.22	642.22	1130.66	190	16.88

RESULTS AND DISCUSSION

Based on the tests conducted on the fibre reinforced concrete following results wereobtained

CONVENSIONAL CONCRETE:

Table no 5.1 Compressive strength of conventional concrete

S.NO	Cubes	Load(KN)	Compressive strength(N/mm^2)
1	Cube-1	780	34.6

2	Cube-2	785	34.8
3	Cube-3	775	34.4

Average compressive strength at 28 days is about 34.6N/mm^2

Table no 5.2 Split tensile strength of conventional concrete

S.NO	Cylinders	Load(KN)	Tensile strength(N/mm^2)
1	Cylinder-1	210	2.97
2	Cylinder-2	200	2.83

Average tensile strength at 28 days is about: 2.9N/mm^2

HOOKED FIBRE REINFORCED CONCRETE:

Table no: 5.3 Test results for hooked fibre for 7 days

Fibre content	0%	1%	2%	3%	4%
Compressive strength(N/mm^2)	23.56	24.44	25.78	24.89	24
Tensile strength(N/mm^2)	2.12	2.40	2.68	2.26	1.98

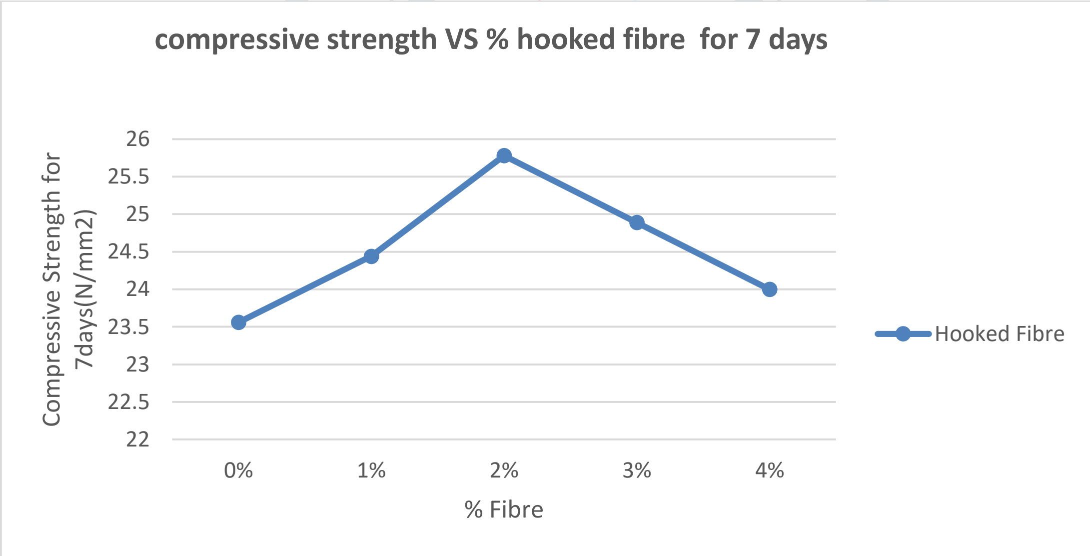

Fig. 5.1 Showing the variation of compressive strength with hooked fibre for 7days

- The above chart shows the variation of the average compressive strength ofconcrete with the variation of the hooked fibres of 0%, 1%, 2%, 3%, and 4%.
- From the test results we can observe that we can obtain the optimumcompressive strength at 2% for 7days of the hooked fibre is 25.78 N/mm^2

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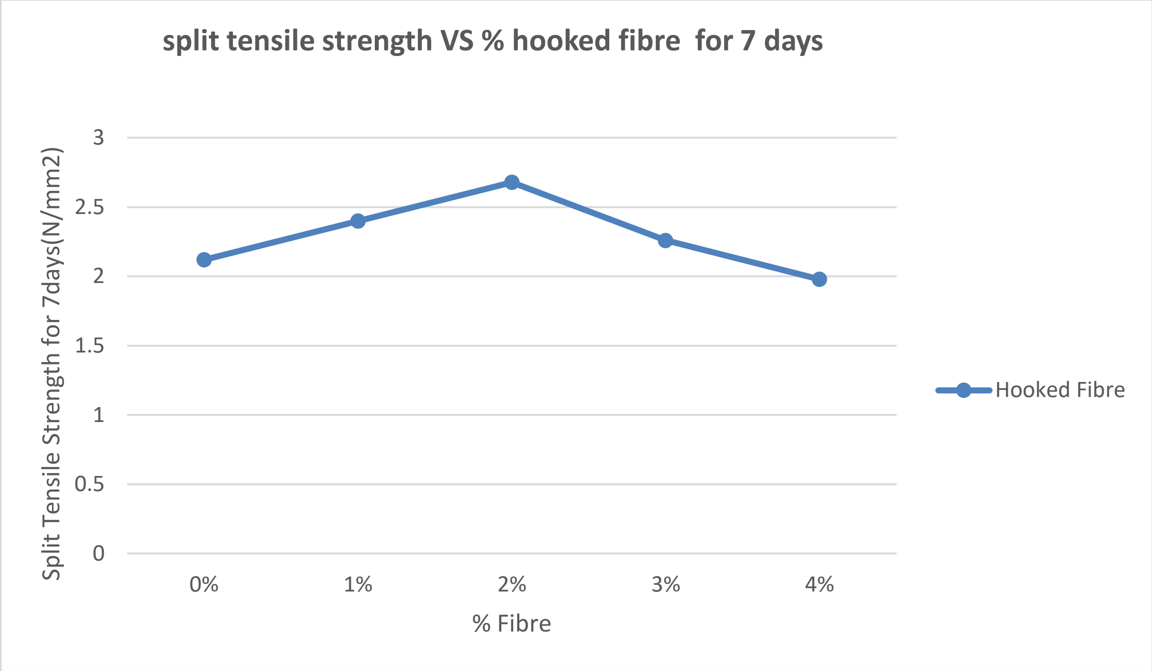


Fig. 5.2 Showing the variation of split tensile strength for hooked fibre content

- The above chart shows the variation of the average tensile strength of concretewith the variation of the hooked fibres of 0%, 1%, 2%, 3%, and 4%.
- From the test results we can observe that we can obtain the optimum tensilestrength at 2% of the hooked fibre for 7days 2.68 N/mm^2

Table no: 5.4 Test results for hooked fibre for 28 days

Fibre content	0%	1%	2%	3%	4%
Compressive strength(N/mm^2)	34.67	35.56	37.78	36.45	35.1
Tensile strength(N/mm^2)	2.97	3.12	3.67	3.25	2.63

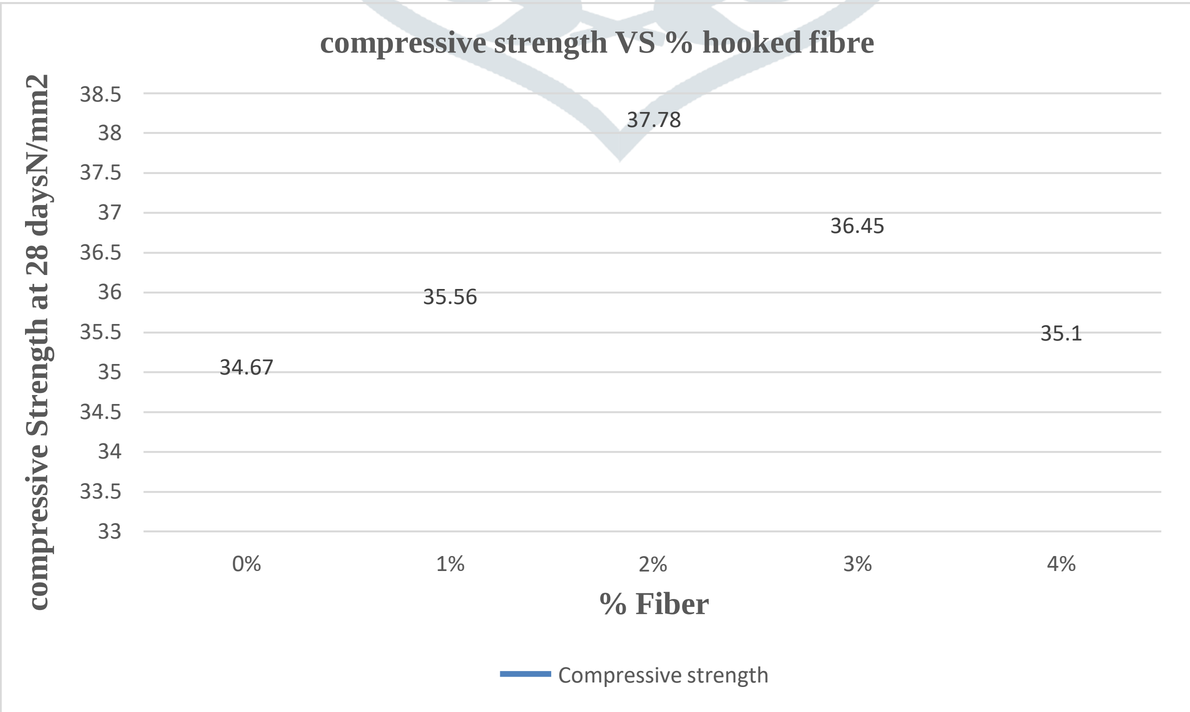


Fig. 5.3 Showing the variation of compressive strength with replacement of hooked fibre

- The above chart shows the variation of the average compressive strength ofconcrete with the variation of the hooked fibres of 0%, 1%, 2%, 3%, and 4%.
- From the test results we can observe that we can obtain the optimumcompressive strength at 2% for 28days of the hooked fibre is 37.78 N/mm2

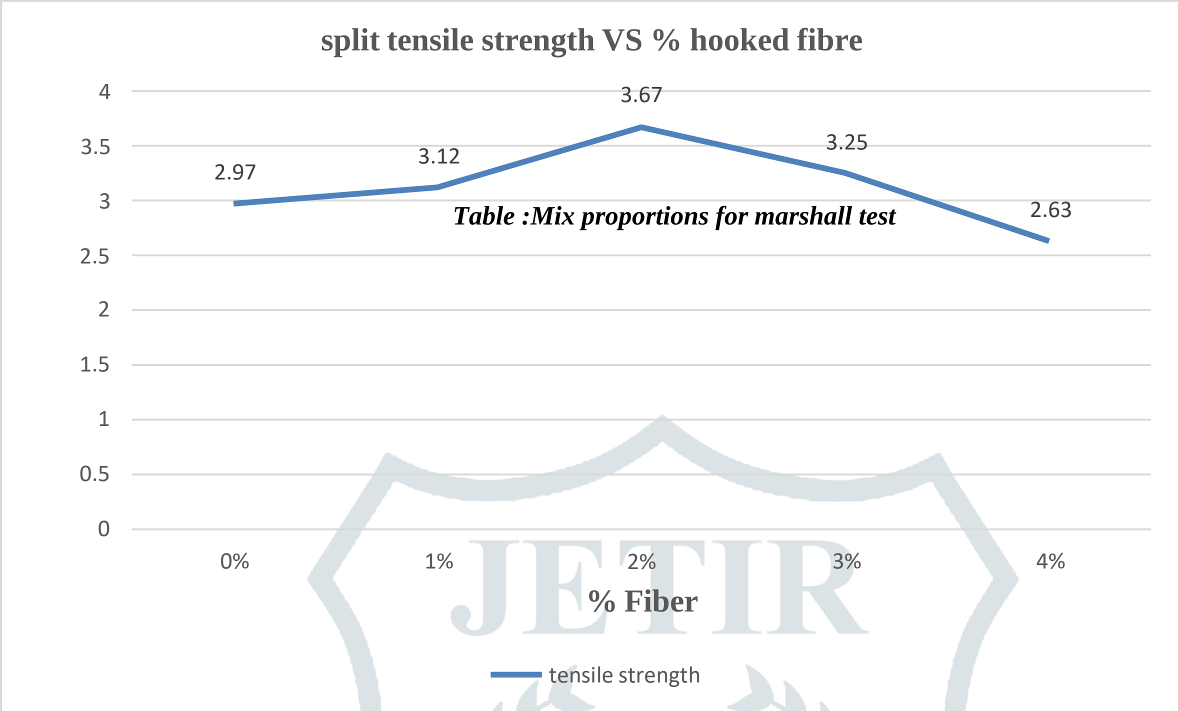


Fig. 5.4 Showing the variation of split tensile strength for hooked fibre content

- The above chart shows the variation of the average tensile strength of concretewith the variation of the hooked fibres of 0%, 1%, 2%, 3%, and 4%.
- From the test results we can observe that we can obtain the optimum tensilestrength at 2% of the hooked fibre for 28 days is 3.67N/mm^2.

CRIMPED FIBRE REINFORCED CONCRETE::

Table no: 5.5 Test results for crimped fibre for 7 days

Fibre content	0%	1%	2%	3%	4%
Compressive strength(N/mm^2)	23.56	24.89	26.67	26.22	24.44
Tensile strength(N/mm^2)	2.12	2.54	2.97	2.82	2.68

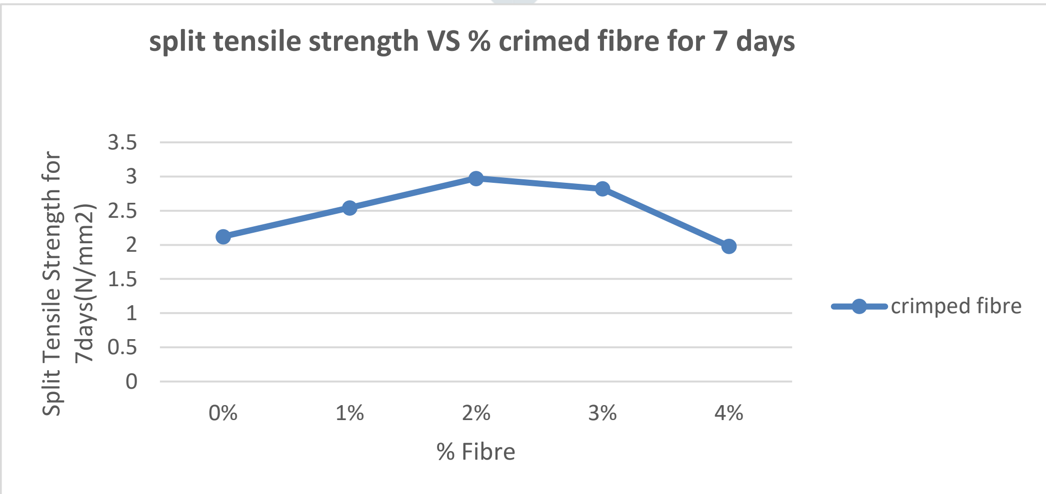
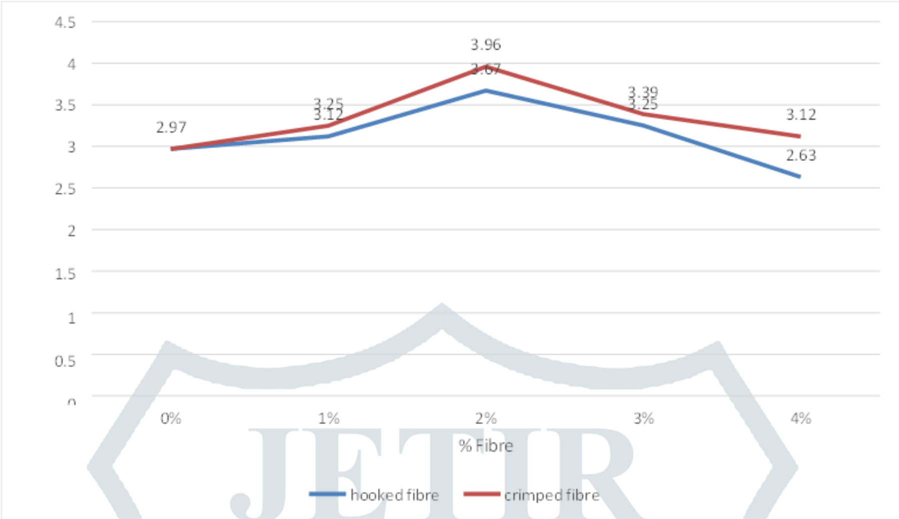


Fig. 5.6 Showing the variation of split tensile strength for hooked fibre content

- The above chart shows the variation of the average tensile strength of concretewith the variation of the hooked fibres of 0%, 1%, 2%, 3%, and 4%.
- From the test results we can observe that we can obtain the optimum tensilestrength at 2% of the hooked fibre for 7days 2.97 N/mm^2

Table no: 5.6 Test results for crimped fibre for 28 days

Fibre content	0%	1%	2%	3%	4%
Compressive strength(N/mm^2)	34.67	36	38.67	37.24	35.56
Tensile strength(N/mm^2)	2.97	3.25	3.96	3.39	3.12



6 CONCLUSIONS AND FUTURE WORK

CONCLUSIONS

Based on the experimental investigation, following conclusions were arrived

- For conventional concrete the average compressive strength at 28days is about34.67N/mm^2 and the average tensile strength at 28 days is about 2.97 N/mm^2.
- The fibre reinforced concrete with hooked fibre gives optimum compressive strengthat 2% of fibre content is about 37.78 N/mm^2.
- And the fibre reinforced concrete with hooked fibre gives optimum tensile strength at2% of fibre content is about 3.67 N/mm^2.
- The fibre reinforced concrete with crimped fibre gives optimum compressivestrength at 2% of fibre content is about 38.67N/mm^2.
- The fibre reinforced concrete with crimped fibre gives optimum tensile strength at2% of fibre content is about 3.96N/mm^2.
- From these results we can observe that both the fibres gives optimum strength at 2%of fibre content but the crimped fibre gives better strength than the hocked fibre.
- So we can conclude that the crimped fibres show better strength properties than thehooked fibre.

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